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Transition from effusive to explosive activity during lava dome eruption: the example of the 2010 eruption of Merapi volcano (Java, Indonesia)

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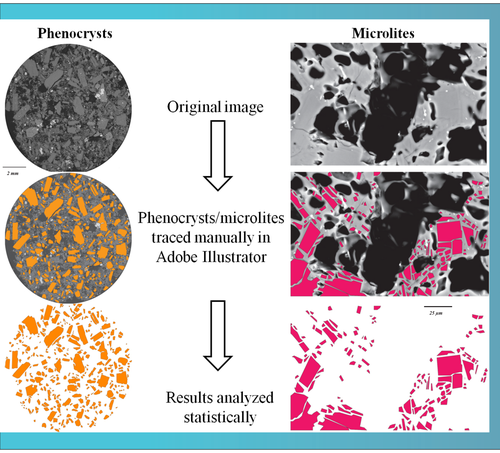
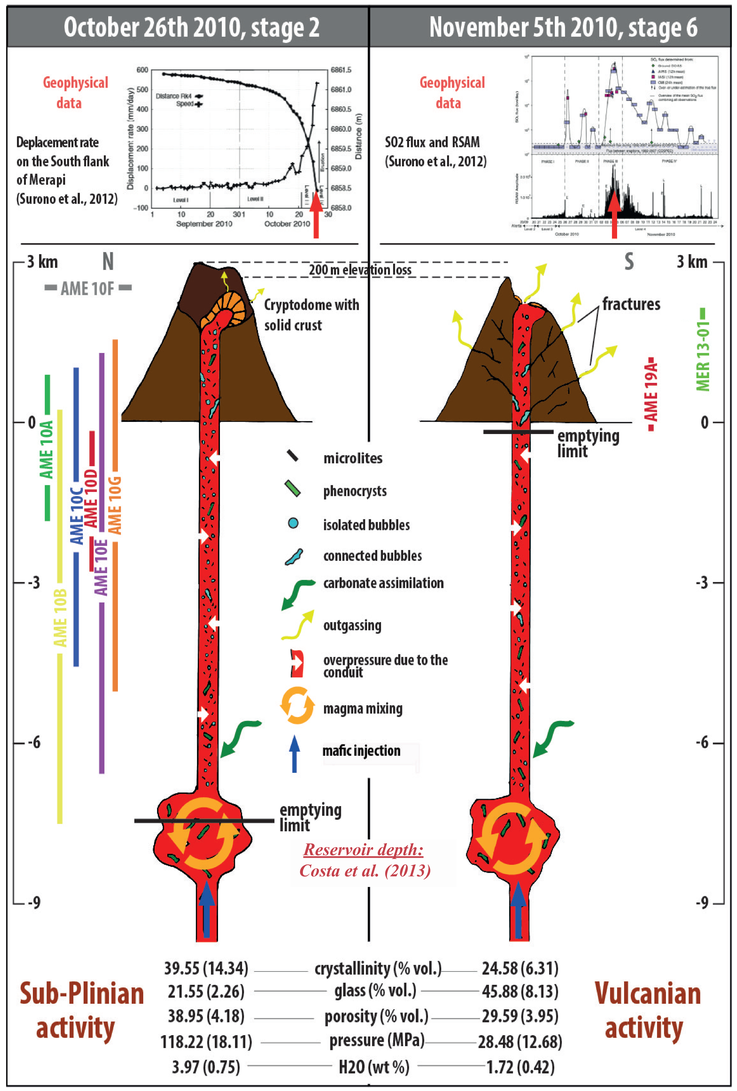
Merapi volcano (Java, Indonesia) is one of the most dangerous volcanoes on Earth. It is known to produce lava domes that collapse in deadly pyroclastic flows because of gravity or auto-explosivity. Even though this volcano is mostly effusive, explosive eruptions occur in its history, most recently in 2010. Two major explosive events occurred that year, the first one on October 26, and the second one on November 05. They produced explosive columns that quickly collapsed in pumice-rich pyroclastic flows that ran up to 15.5 km from the summit. The 2010 eruption was very well observed, making this event a good candidate for investigating the effusive-explosive transition with a full suite of geochemical and geophysical data. The pumice of these two events was analyzed and the data used in a two-step computer model in order to investigate the pre-explosive conditions.
The explosive-effusive transition often occurs at arc volcanoes. The parameters driving this transition (overpressure, eruptive volume, . . .) are known but the relative importance of each parameter remains unclear. This study demonstrates the primacy of overpressure in determining the eruptive mode of the volcano, with volume and other parameters contributing only to the magnitude rather than the character of the event.

1. Analytical Study



We imaged the pumice of the two explosive events using the SEM at the University of Orléans. The aim was then to be able to trace the plagioclase microlites manually, and the oxides and bubbles automatically in order to obtain the glass proportion. At the same time, we obtained the bulk water content of the pumice using an Elemental Analyzer. We then combined these results to obtain the water content of the glass.

4. Preliminary Source Depths



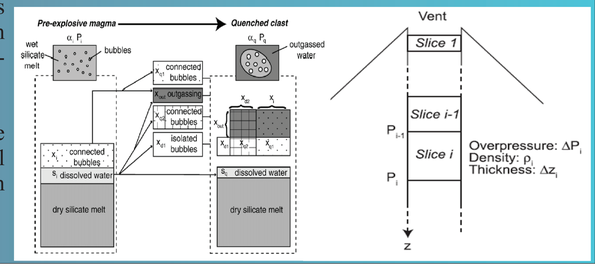
2. Eruptive Depth and Pressure Model

$Temperature_{magma\ -chbr}$ (°C)	950
ρ_{magma} (kg,m^{-3})	2455
$Pressure_{magma\ -chbr}$ (MPa)	300
$X_{H2O\ max}$ (%wt)	7,38

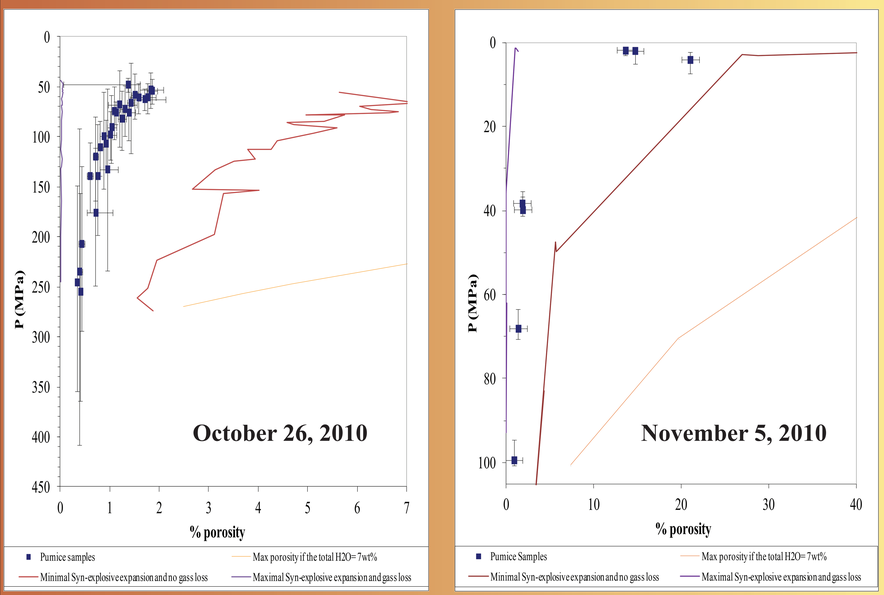
We used the two-part eruptive depth and pressure model developed in Burgisser et al. (2010; 2011) for the 88 Vulcanian explosions that occurred at Soufrière Hills (Montserrat) in 1997.

The first part of the model uses our textural analyses to obtain the initial pressures and porosities of our samples.

Then, the second part of the model determines the initial depths of the samples based on these parameters.



3. Results



5. Possible Eruptive Sequence

Before the explosive event of October 26, a cryptodome was growing in the south flank of the volcano. The pressure induced by this growth and the plug sealing the conduit generated a large overpressure (5- 20 MPa assuming elastic conduit walls) that led to the explosion. The explosion sampled the conduit to 11 km depth. The pyroclastic flow associated with this event was pumice-rich and ran up to 7 km from the summit.

On November 5, after several events, the system was probably semi-open to degassing. The explosion sampled the conduit to a much shallower depth (up to 3 km) than on October 26. The pyroclastic flow associated ran up to 15.5 km from the summit.

It is interesting to consider why there were no stable eruptive columns for either event. The eruptive volumes were fairly small (6-10x10^6 m^3). Small eruptive volumes can't feed a stable eruptive column, so this led to an early collapse.

Eruptive volume is a key parameter for the creation of a stable eruptive column, but does not influence the explosive-effusive transition. The overpressure on the other hand has a major role. With a system closed to gas, it is possible to induce a large overpressure leading to an explosive eruption even at volcanoes that normally have effusive activity, such as Merapi.

Carbonate Assimilation ?